of the petals. The results are complicated, and not readily summarised, but they confirm a generalisation already established by work in hybridisation among both plants and animals: that "views on the presence and action of factors obtained by an investigation of one single crossing are liable to modification when one of the forms investigated is crossed with a third form. Hence it is necessary to cross the same form with more than one partner in order to arrive, step by step, at the truth."

MATHEMATICS AND PHYSICS AT THE BRITISH ASSOCIATION.

THE first of the two organised discussions arranged for this section was on "Gravitation." The discussion followed immediately after Prof. Whitehead's presidential address, and it happened that the arrangement was appropriate, for the president's exposition of the logical texture of geometry had carried us far from the ordinary conceptions of space, and paved the way for the revolutionary ideas associated with the space-time world of Einstein and Minkowski. Mr. E. Cunningham, who opened the discussion, and Prof. A. S. Eddington, who followed, dealt with Einstein's recent work, which brings gravitation within the scope of the principle of relativity. If an observer is in a closed lift, it is well understood that an acceleration of the lift upwards is exactly equivalent to an increase of the force of gravity, so far as mechanical phenomena inside the lift are concerned. There would, however, be minute differences in the optical phenomena according to the ordinary theory; relatively to the accelerated lift the path of a ray of light would seem to be curved, whereas for the stationary lift it would be straight if the increased gravitational field makes no difference. Accordingly, the first suggestion towards a relativity theory which shall include gravitation is that the path of a ray of light must be bent by the gravitational field, just as it is apparently bent by an acceleration of the framework of reference. The curvature to be expected is extremely small—amounting to a change of direction of $1{\cdot}7''$ in the case of a star seen close to the sun's limb—and it has not been possible to prove or disprove the hypothesis directly. Meanwhile the theory has been elaborated and generalised by Einstein, who has at length been able to throw the laws of motion, of electrodynamics, and of gravitation into a form which makes the sequence of phenomena entirely independent of any particular framework of reference. The result has been to yield a very striking confirmation of the theory, for it is found to predict a motion of the perihelion of Mercury amounting to $43''$ per century—just the amount of the hitherto unexplained discordance. The new theory removes what is probably the most celebrated of the few cases of failure of gravitational astronomy. The discussion afterwards turned to the experimental side. Dr. P. E. Shaw gave an account of his experiments which appear to indicate a change in the constant of gravitation with temperature, and Prof. R. A. Sampson urged that astronomical evidence is not capable of denying this possibility. Dr. W. G. Duffield read a report of the Committee on the Determination of Gravity at Sea, considering especially the difficulties attending the use of the aneroid method, and the possibility of improvements in future attempts.

A paper by Sir Ernest Rutherford on the "X-Ray Spectra of the Elements" was of special interest. He referred particularly to the researches of Siegbahn and Friman, who have extended the work of Moseley to the elements of high atomic weight from gold to uranium by examining the L spectra. It appears that there are ninety-two elements up to uranium. By finding the atomic number of lead it has now been possible to assign the whole series of radio-active products to their places in the scheme. Sir E. Rutherford further described the work done in America with the Coolidge tube, which provides a steady high voltage. It is found that the maximum frequency of the rays which can be obtained follows closely the quantum relation $Ve=h\nu$, the accuracy between 20,000 and 100,000 volts being one per cent. To excite the characteristic radiation of a substance a rather higher voltage is needed than that given by the quantum relation, as though it were necessary to expend some energy in disturbing an oscillator.

Prof. H. H. Turner read a paper on the "Measurement of Time," dealing with daylight saving and justifying the innovation from a scientific point of view. The paper elicited an interesting speech from Prof. J. Perry, who admitted that he had formerly rather thoughtlessly opposed the scheme, and urged the warning against being led by authority in science. Other members, however, professed themselves still unconverted.

Prof. T. H. Havelock gave a review of recent work on the "Propagation of a Signal in a Dispersive Medium." He described the approximate methods of calculation which have been used, showing the relation between the recent methods of contour integration and the older work of Hamilton and Kelvin. The precise nature of the "forerunner," or minute disturbance which travels through the medium in advance of the main signal, is a matter of special difficulty, and an exact solution for any particular cases that may prove tractable would be a great help towards progress.

The absence of several speakers who had been expected to take part rather detracted from a discussion on "Osmotic Pressure," opened by Prof. A. W. Porter. There were many other interesting papers, most of which we must pass unnoticed for want of space, but special mention may be made of Prof. J. C. McLennan's paper on "Ionisation Potential," continuing and extending the results communicated last year; also of Sir F. W. Dyson's "Mean Parallaxes of Stars of Different Magnitudes," which in the main confirm the well-known formulæ given by Kapteyn in 1901. At a separate meeting of the department of mathematics Prof. G. N. Watson gave a general survey of the recent developments of the theory of asymptotic series.

A new departure, which it is hoped may lead to important results, was the formation of a committee representing Sections A and E to consider the needs of geodetic research. This arose from the presentation of a report by Col. Close, Sir F. W. Dyson, and Col. Hills, prepared at the request of the Organising Committee of Section A. The report brought out clearly the lack of organisation and general neglect of higher geodesy in this country, and there was a unanimous feeling that steps should be taken towards the constitution of some committee or association responsible for stimulating this branch of science.

THE BRITISH ASSOCIATION AT NEWCASTLE.

SECTION D.

ZOOLOGY.

ABSTRACT OF THE OPENING ADDRESS BY PROF. E. W. MACBRIDE, M.A., D.SC., F.R.S., PRESIDENT OF THE SECTION.

THE decision of the Organising Committee to devote the sittings of the section chiefly to the economic and medical applications of zoology must not divert us from the task of research into fundamental laws. The laws of heredity had been intensively studied for the last twenty years by selective mating, but the study of the laws governing the development of the germ into the adult organism—in a word, of experimental embryology—might eventually throw a great deal of light on the laws of heredity.

After alluding to the work of His, who sketched out the programme of the new science, Prof. MacBride described the work of the first experimenters—Roux, Hertwig, and Driesch—in some detail. He pointed out that the results obtained by these zoologists led them to conclusions about the nature of development which were fundamentally opposed to one another; for Roux, having produced half-embryos by destroying one blastomere of the two-cell stage of the frog's egg, supported the principle of "specific organ-forming regions of the germ," whilst Driesch, having reared a perfect Echinoderm larva of diminished size from one of the first four blastomeres of an Echinus egg, asserted that "the fate of a cell was a function of its position in the embryo," and in this conclusion he was supported by Hertwig, who attempted to interpret Roux's results in a different manner. Even Roux admitted that although half-embryos were formed at first, if they survived they regenerated the missing parts; Roux accounted for his results by supposing that each region of the germ had its peculiar organ-forming substance, or "idioplasson," which conferred on it the power to develop into a definite organ; the regeneration of lost parts he attributed to a special substance, which he called "reserve-idioplasson," which came into play only when mutilation had occurred. Driesch assumed, on the other hand, the existence of a purposeful "entelechy," or "psychoid," inhabiting the living material, and even when, as in his experiments with Ctenophore eggs, he found that isolated blastomeres gave rise to partial larvæ, he did not conclude that definite organ-forming substances were localised in each of the first eight blastomeres; but rather that in these eggs the cytoplasm was so specialised or "stiffened" that the indwelling entelechy could not mould it to its will.

The definite proof of the existence of *organ-forming substances*—a proof which was regarded as one of the great advances made by experimental embryology—was brought by Crampton and by Wilson in their studies of the developing eggs of Mollusca. In the developing egg of Dentalium and of some other Mollusca the first cleavage appeared to divide the egg into three cells, but one of these cells was a mere protrusion devoid of a nucleus, termed the *first polar lobe*, which was reabsorbed before the next cleavage. At the next cleavage five cells were apparently produced, but again one of these was a transitory *second polar lobe*, which melted into one of the four blastomeres before the cleavage to form eight cells began. If the first polar lobe were cut off, the egg developed into a trochophore larva, which was devoid of the apical plate and apical tuft of cilia and also of mesoderm, and of the whole post-trochal region. If the second polar lobe were cut off, a trochophore larva was formed, provided with apical plate and apical tuft, but devoid, as before, of mesoderm and of post-trochal region. The conclusion was inevitable that the specific material for the apical plate and post-trochal region was contained in the first polar lobe, but that the second polar lobe only contained the necessary material for the post-trochal region.

Driesch's objections to this conclusion were founded on the difficulty of conceiving what an organ-forming substance could be like, it being very difficult to picture a substance the molecules of which had the power of "crystallising" into organs, such as, for instance, arms and legs. But if we fell back on our ultimate conception of what we meant by "explanation," we found that it always consisted in comparing a less familiar phenomenon with one about which we thought we knew more. Driesch's entelechy was really an attempt to compare the forces which organise development with the purpose of an intelligent being who wanted to build a house, and, in principle, no fault could be found with it. The great difficulty about it was that this comparison does not help us to understand in the least a large number of phenomena which could be far better "explained" by the theory of organ-forming substances, even although we could not tell what these substances were like. In the development of the Ascidian, *Cynthia partita*, as described by Conklin, the cytoplasm was rendered slaty-blue by inclusions of yolk, and in its outermost zone were numerous particles of bright yellow pigment. Before fertilisation the large germinal vesicle burst, and its contents formed a cap of clear fluid at one pole of the egg. The spermatozoon entered at the opposite pole, and then the clear substance and the yellow pigment were drawn down to meet it, and eventually formed two concentric crescents round the lower pole of the egg. Subsequent development made it plain that the clear substance gave rise to the ectoderm, the slaty-blue cytoplasm to the endoderm, and the yellow material to the mesoderm of the Ascidian tadpole. If one of the first four cells of the segmenting egg were killed, the other three continued their development, and an imperfect embryo was produced; if this cell happened to be one of the two containing yellow substance, a tadpole was produced which had muscles only on one side of its tail. Clearly in this case the organ-forming substances were visible to the naked eye, since they were distinguishable in colour, and their segregation in different regions of the embryo was the real cause of the *differentiation of the germ-layers*. In this process the individual cell was not a unit of any importance; both notochord and nerve-cord arose from the same group of cells, termed by Conklin *chorda-neural cells*; but the cytoplasm of these cells consisted of clear and blue portions, and in the subsequent divisions the clear portions were added to the ectodermic neural plate, whilst the blue portions became the endodermic notochord.

Driesch explained phenomena like these by asserting that these substances were the *conditions*, not the *causes*, of the development of organs; but another experiment, due to Morgan, which had been repeated in the laboratory of the Imperial College of Science, appeared to dispose completely of the idea of there being an intelligent entelechy presiding over development. This experiment consisted in fastening frogs' eggs to a slide, with the black pole uppermost, and fertilising them in this position. When the eggs had divided into two another slide was laid on the top of them and clamped in this position; the whole preparation was then inverted and allowed to develop for five or six days in this position. At the conclusion of this period a double-headed, or double-tailed tadpole was produced. In this case nothing was added to the egg, but the dark substance, which was specifically lighter than the white substance which constituted the rest of the egg, had readjusted itself in each cell under the influence of gravity, in a similar manner to what it would have done in the whole egg if this had been inverted before division into two had taken place. Hence the condition of the formation of a frog embryo must be the *proper spatial relationship between two organ-forming substances*.

If we adopted the view that organ-forming substances were the all-important agents in development, it became of the utmost importance to learn more about them. Observation of the developing egg of Ascaris showed that the relative proportion of such a substance in one cell as compared with its quantity in a neighbouring cell could determine the fate of the cell. This egg divided into two cells at its first cleavage, one of which produced the ectoderm and the other the internal organs. Boveri showed that if these eggs were fixed to a slide which was inserted in a centrifugal machine and a rapid rate of rotation maintained whilst the egg developed, some of them the axes of which happened to lie exactly in the radius of rotation divided into two equal cells, both of which formed internal organs, and neither of which behaved like the cell in the normal embryo, which produced ectoderm. The slightest obliquity of the egg axis to this radius caused the egg to undergo normal development. This experiment, which had been repeated by us in the Imperial College of Science, showed that some substance was present in greater quantity on the outer part of the egg, so that the upper of the first two cells received more of it than the other, and was thus determined to form ectoderm, but that when under stress of the centrifugal force the division plane separating the first two blastomeres took up an exactly radial position, so that this substance was equally distributed to both cells, neither developed into ectoderm.

The question where these substances were formed was of great importance. *A priori* considerations suggested that they must emanate from the chromatin of the nucleus, since the father was as potent in heredity as the mother, and his contribution to the zygote consisted merely of a mass of chromatin. This conclusion was confirmed both by observation and experiment. In the unripe egg of Cynthia, Schaxel had shown that streams of chromatin poured from the nucleus into the cytoplasm, and if the unripe egg of Ascaris was subjected to the most violent centrifugal force, so that it lost large portions of its substance, and was afterwards fertilised, it gave rise to a normal embryo of diminished size, showing that its cytoplasm was not yet organised as was that of the ripe egg, the different development of which under the stress of centrifugal force we have just described. The pressure experiments of Driesch and Hertwig, in which, by allowing eggs to develop in cramped positions, they disarranged the normal order of the nuclei, showed that the nuclei of the segmenting egg were alike, each possessing all the potentialities of the species, for these distorted eggs when relieved from pressure developed into normal embryos, although the nuclei had assumed abnormal positions, and it was the relative position of the *substances* produced by these nuclei, not of the nuclei themselves, which determined differentiation. Sometimes, as in Herbst's famous experiment of allowing Echinus eggs to develop in seawater to which salts of lithium had been added, it was possible to inhibit the formation of one of these substances and produce an embryo consisting entirely, or almost entirely, of endoderm. The formation of these substances appeared to last for only a short period; after that, the nuclei appeared to be without formative influence on the cytoplasm, but in animals like Polyzoa and Ascidians which bud, this budding could be best explained as due to a renewed production of organ-forming substances by the nuclei. These substances were often not distributed to the formative tissues of the bud in the same manner as in the embryo, and hence the development of the bud often followed a different course from that initiated by the embryo. The "post-generation" of the missing half, observed by Roux in his half-tadpoles, and by Chun and Mortensen in their half-Ctenophore larvæ, could be explained in a similar way by postulating a renewed activity of the nuclei at the cut surface. Considerations of this kind were fatal to the conception of Weismann of the definite segregation of germ-cells from body-cells at the beginning of development, dependent on a differential division of nuclei, or, as he termed it, the formation of definite *germ tracks*. Indeed, Gatenby had lately shown that in the frog the supposed germ-cells which were segregated at an early period of development would scarcely supply the needs of the first spawning season, and that the eggs needed for subsequent seasons were formed by the metamorphosis of ordinary peritoneal cells.

Next to the discovery of organ-forming substances perhaps the greatest discovery in experimental embryology was the influence which the primary organs exerted on each other's further development. The first discovery of this influence was due to Herbst, who showed that if the ocular peduncle of a shrimp were amputated, the animal was able to regenerate a new one, as was the case also if the other limbs were cut off; but that if the optic ganglion was also removed then an antenna-like organ was regenerated in place of an eye. From this experiment the conclusion was forced on us that in the normal development of the shrimp the ectoderm was caused to mould itself into the retinulæ and crystalline cones of the eye by some influence emanating from the optic ganglion. This influence must be some chemical substance emitted into the blood and comparable to the hormones, which we know to be emitted by organs like the thyroid gland, which so powerfully influence growth in man. Another instance of the same thing was afforded by the experiments of Lewis; this observer cut off the optic vesicle from the brain of a young tadpole, and pushed the amputated organ backwards under the skin to a new position; the wound healed up; no lens developed in the normal position, but a lens was developed from the skin situated over the optic vesicle. This experiment proved that no part of the skin was predestined to form the lens of the eye, but that any part could form the lens if acted on by the emanations from the optic vesicle beneath. A third instance was discovered from experiments in the Imperial College of Science in the rearing of the larvæ of the sea-urchin, *Echinus miliaris*. In normal development the rudiment of the water-vascular system or "hydrocœle" was formed from the cœlomic vesicle on the left side of the larva. Above it the ectoderm became invaginated so as to form the amniotic pit, from the floor of which were developed pointed spines and tube-feet, whilst beneath the hydrocœle a series of pockets grew out from the left posterior cœlomic vesicle which developed into Aristotle's lantern. On the right side of the larva two calcareous plates were developed bearing square-topped spines and pedicellariæ. Under the influence of certain stimuli the larva could be made to develop a second hydrocœle on its right side, and when this took place, from the octoderm of the right side and from the right posterior cœlomic vesicle respectively a right amniotic pit with spines and tube-feet and a right Aristotle's lantern were developed. In other circumstances the formation of a hydrocœle could be inhibited altogether, and then calcareous plates bearing spines were formed on both sides of the larva.

If the second or right hydrocœle was small, it failed to inhibit the formation of plates bearing spines and pedicellariæ proper to the right side, so that both hydrocœle and pedicellariæ could be present together on the same side. The only possible explanation of these facts was the view that any part of the ectoderm could form an amniotic pit, and either left or right cœlomic vesicles could form an Aristotle's lantern, if acted on by influences emanating from the hydrocœle, and that both sides of the larva were really alike in their constitution, and that in the total absence of a hydrocœle each produced calcareous plates with spines.

The discovery of the profound influence exercised by the growing tissues of the embryo on one another lent some support to Dr. J. T. Cunningham's theory of the inheritance of acquired qualities based on the facts known as to the influence of hormones on the growth of the human body. If it should turn out, as seems, from the results of these experiments, to be the case, that the production of hormones was not at all confined to certain ductless glands, but was a much more widespread phenomenon, we could understand that if, through an alteration in external conditions, a change was induced in some tissue, its chemical emanations would be altered. If, further, these altered substances, circulating in the body fluids, were ultimately stored up in the germ-cells, then eventually as the germ developed the corresponding alteration would be produced in the tissues of the young animal, even before it was exposed to the changed environment.

Of course, the proof that such an influence of a changed environment on subsequent generations was possible must ultimately be found by experiment, and the inherent difficulty of such experiments was very great, but some suggestive work by Kammerer on the inheritance of colour in Salamanders seemed really to supply positive evidence in favour of the inheritance of environmental influence.

In conclusion, let us bear in mind that the hormone theory of the inheritance of acquired characters which a study of experimental embryology inclines us to regard with favour was in principle identical with the theory of "pangenesis" propounded by the founder of modern biology, Charles Darwin.

UNIVERSITY AND EDUCATIONAL INTELLIGENCE.

LONDON.—A series of public lectures, under the general title of "The University and the Nation," will be delivered on Wednesdays, at 5.15 p.m., at King's College. The lectures will be as follows:—October 25, The Root Fault in the English Attitude to Education, Dr. Burrows, Principal of King's College; November 1, Science and Industry, Mr. James Swinburne; November 8, Science and the Training of the Citizen, Principal Griffiths; November 15, The Spiritual Appeal of the Humanities, Mr. A. C. Clutton-Brock; November 22, The Intellectual Groundwork of Politics, Dr. H. A. L. Fisher; November 29, Education—the Curse of Convention, Mr. Graham Wallas.

Dr. Marie Stopes will begin a course of six lectures and demonstrations on "The Bennettitales" on October 17, at 5 p.m., at University College. The course will be illustrated by lantern-slides and specimens, including microscopic sections of new species. Further particulars can be obtained from the secretary of University College.

Prof. J. A. Fleming will deliver a public lecture on "Long-Distance Telegraphy and Telephony," at University College, on Wednesday, October 18, at 5.30 p.m. This lecture is open to the public without fee or ticket.

OXFORD.—On October 7 the Vice-Chancellor (the Very Rev. T. B. Strong, dean of Christ Church), on entering upon his fourth year of office, delivered the customary address. After mentioning that about 10,500 members of the University were serving in the Army and Navy, and about 500 were in other Government employment, he spoke of the distinctions gained by them in the present war, including 9 V.C.'s, 120 D.S.O.'s, and 700 mentions in despatches. Passing on to speak of the educational deficiencies which had been disclosed by the war, he said that the University must find some way to remedy the neglect of the claims of natural science. Average people were not likely to become advanced students of science, but they wanted everybody, including the average people, to be aware of, or in some degree to understand, the scientific point of view. The country would have to give up its prevalent attitude of distrust towards expert knowledge. The new statute relating to the Honour School of Chemistry was an attempt by the University to put the study of that science on a more satisfactory footing. But it should not be forgotten that the majority of Oxford men would be engaged in the work of administration, for which the knowledge of men was essential.

The University has received with much regret the news of the death of Mr. Horace Hart, who for more than thirty years conducted, as controller, the business of the University Press with marked ability and success.

A MEETING of the Association of Technical Institutions will be held in London on Friday and Saturday, October 20–21. For some time it has been felt that the members of the association should meet together to consider educational questions having special bearing on the work of technical schools and colleges. The governors of the Imperial College of Science and Technology, South Kensington, have placed rooms in the college at the disposal of the association for the purposes of the conference. Sir Alfred Keogh, K.C.B., president of the association, will preside over the meeting. The Right Hon. A. H. Dyke Acland, chairman of the Executive Committee of the Governors of the Imperial College, will welcome the delegates to the college at their first session. On the Friday morning Lord Haldane will deliver an address on "Education after the War, with Special Reference to Technical Instruction." This will be followed by a paper by Sir Trevor Dawson (of Vickers, Sons and Maxim) on "Education after the War, with Special Reference to Engineering Instruction." The afternoon of Friday will be devoted to a discussion of the address and paper. On Saturday, October 21, Major Mitchell, director of the Regent Street Polytechnic, London, will read a paper on "What Can be Done to Train Disabled Sailors and Soldiers in Technical Institutions," to be followed by a discussion.

IN presenting the Education Estimates to the House of Commons on July 18, the President of the Board of Education said that in addition to three committees of experts to investigate different educational questions, a fourth committee was to be appointed which would be a Reviewing Committee. The three expert committees are dealing respectively with the education and care of young persons after the war, and the position of science and modern languages in our educational system. Mr. Bonar Law stated, in the House of Commons on October 10, that the Reviewing Committee, which will be a sub-committee of the Prime Minister's Reconstruction Committee, has for its terms of reference:—"To consider the system of education as a whole; to review and formulate from that point of view proposals for developing it, particularly in directions indicated as desirable or necessary by experience gained during the war, and with special reference to:—(*a*) Proposals prepared before the war for the development of the national system of education; (*b*) the memoranda already submitted by the Education Departments for the consideration of the Reconstruction Committee; (*c*) any proposals submitted hereafter from the departments, or from special committees, or from other responsible organisations; and to recommend from time to time such action, whether by way of legislation or otherwise, as may be practicable." It is understood that this Reviewing Committee will consist of Cabinet and ex-Cabinet Ministers, and possibly of some other persons to be called in for advisory purposes, but no announcement has yet been made as to the actual membership.

AT the invitation of the Universities of Leeds and Sheffield a party representative of the Institute of Journalists, the Circle of Scientific, Technical, and